

AN
E S S A Y
ON
CRITICISM.

In the Course of which
The THEORY of LIGHT,
AND
The GRAVITY of the EARTH,
Are particularly considered.

By THOMAS KIRBY.

LUKE MILBOURNE, *the fairest of Criticks, who, when he wrote
against Mr. Dryden's Virgil, did him Justice in printing at the
same Time his own Translations of him.*

Notes on the Dunciad.

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TO THE

R E A D E R.

THE reason for offering you this fragment, or scrap, or what you please to call it; is because I have not leisure to digest the whole, or half, or indeed the quarter part of what I have to say on the science of Astronomy, into a method fit to be laid before you, most of my minutes being either lost or mislaid. But if you should chance to like this, I can furnish you with more, if not, I shall be sav'd the trouble of revising the part which is wanting.

Making my appearance from the press, is not the method I should have chose, could I have had the advice or assistance which I apply'd for, to have introduced what I have to say, otherwise. But the matters I am to treat of being understood by so very few, and the doctrine and authors I oppose, of so very great and established reputations, I do not much wonder no one cares to be concerned with me. Yet one would think it must excite peoples curiosity to hear what a person so little conversant in literature as I am, can have to say on a science which has engag'd the attention, and been the study of the greatest and most learned men, in

almost all nations and ages of the world, and yet different from them all.

The arguments I have reply'd to on the subject of light, and the tides, are almost all of them taken from *Barrow's Dictionary*, so that I oppose other mens opinions of Sir *Isaac Newton*, rather than himself: I have never * read any of that illustrious author's writings, otherwise than in extracts by other people.

If I remember right, instead of seven days and a half, there are eight days and three quarters less between the equinoxes in winter than in summer; but as my minutes relating to them, I believe, were burned, I cannot be certain; but my design is to make the equinoxes a chapter by themselves, which, perhaps, will be the next thing I shall offer to you; wherein I shall shew the reason why there are eight days and three quarters less between them in winter than in summer, and the cause of the precession, neither of which are known in the present astronomy; with some other remarks relating thereto, very necessary to be known.

It would be difficult, perhaps, impossible, for me to pretend to anticipate all the objections that may be raised, when I assert that light is nothing more than a reflection from all opaque bodies, or to use all the arguments that may be urged in its favour; I have therefore only selected a few on both sides of the question. If I have placed any part of the present theory in a disadvantageous light, or advanced any thing that is fallacious on my own part, the advocates for Sir *Isaac Newton*, (if any should

* *Surlyboots.*] Pshaw! I thought he was some such fellow; censure an author he never read! I suppose next he will find fault with paintings he never saw, and music he never heard.

should not think his time ill spent in doing it) will have a fair opportunity of bringing me to an account. And all that I desire of them, is, that they would do as I have done, *i. e.* publish what they have to say, and put their names to the performance.

Since my saying I would shew the reason why there are eight days and three quarters less between the equinoxes in winter than in summer, and the cause of the precession, I have seen in the Review for *October*, remarks on a treatise wherein the Reviewers seem to be quite decisive; and intimate that the author has said all that is necessary for the investigating the cause of the precession, and the nutation of the earth's axis; which *all*, in my opinion, amounts to no more than one error founded on another, neither of which, were they truths, has the least relation, or can any way be concerned in the matter. For I will venture to say I am certain, was the earth as flat as a grindstone, its figure could be no ways concerned in being the cause of the precession, and whether it is a spheroid or not, I believe nobody knows. As I am unacquainted with the manner by which these gentlemen ascertain the length of a degree, I will present you with what I think the most accurate method of doing it, and leave you to judge for yourself. And that is from a solar eclipse, because then we have day-light; and supposing at such a time two astronomers should be plac'd to take the immersion at sixty miles, or near it, distant from each other, both of them exactly under the parallel of the equator, even then, if their clocks, watches, &c. should be false, or differ but one second of time from each other, the error in distance would be a quarter of a mile, which in the girt of the globe would be ninety miles, and would shorten or
lengthen

lengthen its diameter thirty miles, which is nearly equal to the matter in dispute; for the difference of the diameters is said to be but thirty-four miles. Or was it to be granted that their clocks, watches, &c. did miraculously agree and keep time together, the time of a second is hardly distinguishable on their dial plates; besides, were two astronomers to stand at each other's side to take an immersion, I don't imagine they would agree to the time of its taking place so near as to one, two, or three seconds. This is without mentioning the difficulties which would arise in measuring the ground after the observation was taken; which alone would be sufficient to make me doubtful of their measures.

Whether there is any better method for ascertaining the length of a degree under the equator, or not, is unknown to me, but I believe there is not; therefore I think it needless to trouble you with any thing concerning the measures for the length of a degree under any meridian, for the polar diameter; because, granting them to be quite accurate, yet, for the determination of the difference, they must be the same under the equator.

The cause of the precession, and other particulars relating to the equinoxes, are in reality interesting subjects; the want of knowing them has been the cause of the last regulation of time being very badly done, and has made a bad cause worse than it was before; but the error is in some measure compensated, as it makes us keep company with our neighbours, and go all wrong together.

Positiveness is but an ill recommendation, but I cannot be diffident in matters which are surrounded
with

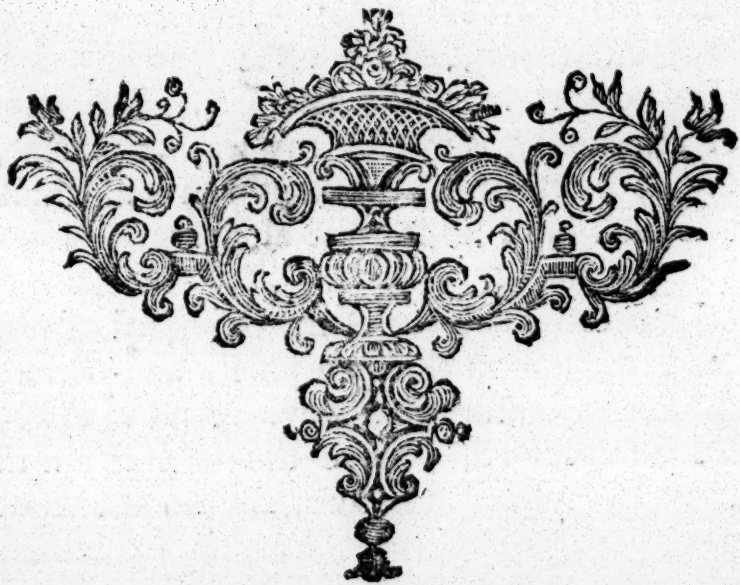
with so many clear evidences of their truth. For it is *falsehood* that requires these broken and patch'd up hypothesis to support it; truth is generally clear and self-evident.

As to the nutation of the earth's axis, I cannot think the authors who mention it themselves believe the earth has any such motion. It looks like an opinion invented on purpose to account for the earth's following the angle of the ecliptic. These gentlemen seem to me to think the earth's equator at the time of either of the solstices is parallel with the equator of the sun, and by the nutation of the axis in its progress, it gradually inclines to the angle of the ecliptic, which is absurd indeed. But perhaps I am mistaken, and do not rightly understand them; and I assure you my design is not to pervert any one's meaning. But as this part of astronomy is out of my way at present, I shall say no more of it; perhaps you will think I might as well have let it quite alone.

But I am too conscious of my disregard of regularity and method in this pamphlet, and therefore must submit to censure that way. And if after all I should be deceived, I have the satisfaction that it is the appearances in nature, and no man's opinion, that has deceived me. For the experiments which I refer to for light, the twilight, and refraction, are all of them to be found in nature. For supposing the universe to be full of orbs, and the sun in the middle of them, (if they were not eclipsed by each other) the hemispheres towards the sun must be enlightened in the manner as I have set forth. And if light does reach beyond the hemisphere of the globes, it must make their shadows conical, and have an effect which will leave light after the body of the sun is hid.

And

And if light does expand itself, and weaken in proportion to the expansion, there must be a gradual increase from darkness to light; and if light had not that gradual increase, the change from light to darkness must be sudden; and if the earth is round, we must see the sun, moon, &c. when they are beneath the horizon; at least I think all and every individual of them must be true.



A N
E S S A Y
O N
C R I T I C I S M.

CRITICISM, rightly used, is certainly of importance to science; its office is, or should be, strictly to examine every thing which is advanced on any art or science, point out its perfections, or blemishes, and praise or censure with candour. A Critic considered in this light is placed in the uppermost seat in the temple of literature, and made a monitor to all mankind; he teaches (if I may be allowed the expression) the anatomy of science, dissects and lays open all its parts, shews its beautys and advantages, and learns us to shun its false appearances and errors.

The capacity and qualifications for such an office, and how far any one on the presumption of his own self-sufficiency has a right to make his judgment the criterion of right and wrong in such matters, I shall leave to others to determine; but thus far I may venture to assert, that criticism, as well as other things, is perverted and abused; that prejudice and spleen sometimes supplies the place of judgment, and that there are Critics as well as Authors of all classes.

For if a young fellow, who is troubled with an itching in his brain, scratches his head till he forces out two or three penny-worth of wit, or what he would have thought to be such, his pamphlet no sooner appears than it suffers a critical persecution. Old *Surlyboots* takes the scent at once, and cries out on it, What abominable stuff have we here? The poor press how vilely is it prostituted! D—n these booksellers they'll publish any thing to get money. What a deal of such like clamour, and all on a matter which none but himself thinks worthy of notice. For supposing the youth for value received has a mind to attempt a panegyric, is it more a crime in him to say fine things (*alias* lies) on his friend in bad verse, than others on theirs in good? Mr. *Pope* has told us that *a lie in prose or verse is the same*, and yet whoever looks over his epistles, epitaphs, &c. (without the help of a lantern and candle at noon-day) may find lies and nonsense too. I remember somewhere to have met with a distich which says,

O London! London! *how just are thy reproaches,*
 Poor whores are whipt, whilst rich ones ride in
coaches.

Which is very much the case with poor liars, and I cannot help saying that magistrates and critics are a very partial set of people. Or supposing the youth to have been tickled by *Cupid*, should any one be offended at a little harmless nonsense in praise of a mistress. Besides, I can tell Mr. Critic, that such performances sometimes serve their authors to very good purposes. Patrons and women are seldom angry, and very often pleased with them. The harlot *Flattery* has charms (when artfully displayed) which few or none are proof against. *Shakespeare* makes *Decius Brutus* undertake
 to

to bring *Cæsar* to the capitol (in spite of augury and *Calphurnia's* dreams, with these words, or something like them,

‘ *Let me alone with Cæsar, I can o’ersway him,*

‘ * * * * *

‘ ————— *I’ll tell him he hates flatterers,*

‘ *Being most of all flattered when I tell him so.*’

Nay, so intoxicating are her wiles, that the gentleman in *Quixote* acknowledges he could not help being pleased with the Don’s praises, tho’ he knew they came from a madman.—Not only so, but to benefactors and mistresses, adulation (as it were) loses its name, and is look’d on as gratitude and gallantry: and there are those in the world who have lived comfortably all their days on the merits of performances for which (arraign’d at the tribunal of truth and justice) they’d deserved to have had their bones broke.

And when such authors write satyr their spleen seldom hurts any but themselves, nay there they may be sometimes very useful, by shewing the persons slander’d the world’s opinion of them, which otherwise they might never have known, and by that means giving them an opportunity of justifying themselves, or amending their conduct for the future.

And in politics, it is not impossible but (like *Sir Martin Marall* in the play) they may sometimes stumble on a useful hint, tho’ not capable of judging of its advantages, or knowing how it should be put in execution; but then others might do it for them.

I would not have it thought I want to justify such authors; what I contend for is, that they are beneath criticism, and indeed a critic must have very little knowledge of mankind who thinks to
deter

deter them from writing by any thing he can say or do.

And when they are quite insipid, which is generally the case, men of sense should consider the itch of writing as an infirmity, and pity 'em ;

' Pity 'em, crys *Surlyboots* again, d—n 'em, ' why ar'nt they brought up to some employment ' and made serviceable to their country. A fellow who could never learn to read nor write ' might cobble a shoe or patch a whole in a coat, ' but being bred in idleness they must turn authors, and be d—n'd to 'em, and plague us with ' their nonsense.'

Once more, Mr. Critic, I say they are beneath your notice ; it is with me a certain sign of cowardise when a man strikes another whom he knows is not able to return the blow. If you would exert yourself, and be (what you would have the world think you, a Critic) there's Sir *Isaac Newton*, he is a dangerous person if he is wrong, every body follows him, therefore the discovering errors in his works (tho' never so minute) will be doing mankind a favour, and keep all right.

Surlyboots.] ' Right ! who dare say he's wrong ; ' that prodigy in science, ornament to literature, ' and honour to the nation and age he liv'd in ?'

Why that to be sure is the fashionable critical language ; but pray when you gentlemen make your comments, panegyrics, &c. on him, where he is extoll'd beyond every thing that is human, do not you think your passing by any part which is not strict and perfectly true, may mislead more people, and consequently do more mischief to science than ever was or will be done by all the dull authors that ever set pen to paper. For if ignorance is a crime in an author, I think it must be rather more so in a Critic.

How-

However, I would not have it thought that I have any dislike to either of you, any otherwise than I would not have you give judgment implicitly, thro' prejudice; nor in matters you do not understand; nor have merit imputed to him where he has not deserv'd it: for that he was a very great man is indisputable, but then he was a man, and a mere mortal as well as his neighbours, and consequently not infallible, nor without his foibles.

Surlyboots.] 'Foibles, 'sdeath what do you mean, 'perfection is no where to be found but in his 'works: sure you know not what you say, or if 'you do, and have any meaning, speak out.

Why then, Sir, I can't help saying (because I think so) that he would have been a much better (tho' perhaps not so great) a philosopher, if instead of pretending to investigate the nature and properties of light, and the cause of the ebbing and flowing of the sea, he had behaved with a little more diffidence, and acknowledged he was not quite master of those subjects.

Surlyboots.] 'Not master! has he not made perfect theories of them both, which has the sanction of all mankind in their favour, and will 'you pretend to dispute them?'

Why, as you say, it is a kind of forlorn hope; but I have ventured too far to go back.

A DISSERTATION on the Theory of Light, in a Dialogue between an Assertor and an Objector.

Assertor.] LIGHT consists of inconceivable small particles of matter of different magnitudes, which are emitted or reflected from every point in the surface of a luminous body, in right lines, and in all directions, with an unparallel'd velocity, and whose power and intensity decreases as the squares of the distance increase. *Barrow's Dictionary.*

Objector.] That light is § emitted or reflected from every point in a luminous body may be true, but that it is material, and consists of inconceivable small particles of matter of different magnitudes, I don't rightly understand; for if they are material, how do they lose their substance and quality, as in the following case. Suppose a room was to be made under-ground (as large as you please) well secured every way, but at one end, and that facing the meridian sun, the roof and floor of such a declivity, that the sun at that time might shine against the farthest end of it, the room must certainly then be full of these particles. Then suppose a door was directly to be shut against the open part, or three or four doors at a distance from each other, so close, and in such a manner, that the light could not pervade them, in such a case I ask what becomes of these particles, for they cannot get out of the room, because the greater power will impel the lesser; and if they do not, how or which way do they lose their substance and quality? For I imagine the room would be totally dark.

Assertor.]

§ Light I think may be said to be emitted from the sun, and reflected from all other bodies enlightened by it.

Affertor.] An answer to this will require some little consideration, therefore we will wave it for the present, and go on with my proofs. That light is a material substance, and what we call a body, is not to be doubted; because we find it something that has motion, or is propagated in time; something that acts upon bodies, and produces great changes and alterations in their natures and forms; something that bodies act upon, by reflecting, inflecting, and refracting it, on their surfaces, and in their pores, and would appear to have all other sensible qualities of matter, were it not that the smallness of the quantity of its particles renders them intirely imperceptible to us. Nor are we to consider light only as a body, but as the most active principle, or most general agent, in nature; and is, perhaps, the true *primum mobile*, or spring of motion and action, in all other bodies. Were the particles of light to be annihilated we should see no marks or footsteps of fire remaining, and therefore no power of motion in bodies; but all things would put on the appearance of lifeless, inert matter, rigid and inflexible, as it would be absolutely cold and dark. *Barrow.*

Objeſtor.] The particles of light are highly obliged to you. You attribute very largely to them. But pray, in that part where you say, 'Were the particles of light to be annihilated we should see no marks or footsteps of fire remaining,' have not you (as the children say) put the cart before the horse? and mean, if all fire was annihilated, we should see no marks or footsteps of light remaining? for that fire produces light is very plain, but that * light produces fire is not quite so clear. But leaving this, you say, that light is a substance

* The burning glaſs ſeems to make light and fire to be one and the ſame thing, rather than prove that light is the cauſe of fire.

substance because it has motion, you will please to explain that part first.

Affertor.] As all the other affections of light, so that of its velocity, was unknown to the ancients, and most of the modern philosophers, who before the time of Mr. *Romer*, were of opinion, that the motion of light was instantaneous, but he and other philosophers about that time, making frequent observations of the eclipses of Jupiter's moons, found the eclipses did not correspond with the calculations founded upon the astronomical tables, where the times are calculated for the distance of the centre of the sun, and consequently where the eye of the spectator must be supposed to be, in viewing the said eclipses, occultations, &c. To illustrate this—*Barrow*.

Objector.] Pshaw! that needs no illustration, the error there is undoubtedly in the astronomical tables, without you think the order of Jupiter's planets wrong, and your tables right. But what is all this to the motion of light; that is what we are upon.

Affertor.] Give me leave, sir. Was it not for the motion of light, these planets would exactly correspond to the times in the tables. For when the earth is between the sun and Jupiter, these eclipses happen 7 or 8 minutes sooner than they ought to do by the tables. And when the earth is beyond the sun, they happen 7 or 8 minutes later. The reason being, that the light of the satellite has further to go in the latter case than in the former, by the diameter of the earth's orbit.

Objector.] Then I find you are quite certain that your tables are right, and that they would correspond with the eclipses was light instantaneous: but to save you the trouble of any further explanation of this ingenious hypothesis, please to answer the following question. Do you really think that the
sun

sun is always existing, and *Jupiter* and his planets receive their light from it.

Affertor.] Certainly the sun gives light to the whole system, and is always existing.

Objector.] If this is true, the instant any one of the sattellites emerge from behind *Jupiter*, the light of the sun must be on it, because we are certain it is on *Jupiter*, and stars farther distant from the sun than he is; and sure it need require no great proof, to say the instant we look at it we see it. And that distance is no way concerned in the matter is quite plain; for I may venture to be positive that the instant we turn our eyes to look at the sun, moon, or the most or least distant of the stars, we see them: so that if you was not quite certain your tables were right, I should suspect they were not. But go on, if you please, let not this interrupt you.

Affertor.] This, tho' a sufficient argument or proof of the progressive motion of light, was yet but an experiment in the gross, and not accurate to determine or define the true rate of velocity, which properly belonged to light, the solution of this noble problem was reserved for the celebrated Dr. *Bradley*, who by reiterated and certain experiments observed that the bright star in the head of *Draco* appeared 39 seconds more northerly in *September* than in *March*, just the contrary way to what it ought to appear by the annual parallax of the stars, which must arise from the velocity of light bearing some proportion to that of the annual motion of the earth. *Barrow*.

Objector.] What does it signify to us if the bright star in the head of *Draco*, instead of 39 seconds is 39 degrees more northerly in *September* than in *March*. It is the velocity of light (only) that we are upon.

Assertor.] I say as before, that the velocity of light must be the cause of that star's being more northerly in *September* than in *March*. *Barrow*.

Objector.] Must be! pray for what reason?

Assertor.] Because we can think of nothing else that can account for it. *Barrow*.

Objector.] Must be! and because you can think of nothing else that can account for it! What sort of argument is this? If you can't, perhaps there are others that can. Or if no one ever does, would you circumscribe the ways of the Almighty to the scanty limits of your understanding: why this is downright profaness, and nothing at all to the purpose.

Assertor.] When you come to understand these matters you'll think otherwise.

Objector.] Probably I may. And now, Sir, leaving out the weight, measure, &c. of light, and how it acts upon bodies and alters their forms (where I hope you don't mean it changes horses into cows) please to explain the magnitude of its particles, and how you know there are different degrees of it.

Assertor.] That the particles of light have not only magnitude, but different degrees of it also, is perhaps one of the most subtle discoveries in all the *Newtonian* philosophy. The comparative terms of greater and lesser, are now as applicable to the particles of light, as to any other bodies: this is absolutely proved by the different refrangibility they are found to have in passing through a prismatic figure of glass or water. For the power of the prism detains the issuing particle, and draws it a little toward the surface; and since this power is the same, it would have the same effect on all the particles of light, if they were of an equal magnitude, because they have all an equal velocity; but since this effect is different among the par-

particles, some being detain'd and drawn aside to a greater distance than others, it follows, they must be less in magnitude to become more subject to the influence of the attracting surface, in like manner as the electric effluvia will act upon and agitate very small and light bodies much sooner than they can move those which are larger. *Barrow.*

Objector.] The power of the prism, you say, detains the issuing particle; then I suppose these inconceivable particles when they travel together, always take care to have with them one smaller than the rest, for an issuing particle, purposely to be detained in your prism. But how if another prism should meet him before he got to yours, and make him a prisoner, what would you do then?

Affertor.] There are always a sufficient number of small particles as well as large ones.

Objector.] How happens it then they are not all detain'd in your prism; I thought the issuing particle being smaller than the rest was the cause of its being detain'd, and drawn aside to a greater distance. Nay, I think it may be inferr'd from what you have said, that all the particles of light, (if they were of an equal magnitude) must be detained in your prism, and then you know there could be none left for any other; but this, as you say, is very subtle, and perhaps I do not understand it. Thus far I know very well, that light, when a prism is held up against the sun, makes an appearance of different colours, as red, blue, orange, &c. and when a misty cloud appears against the the sun, there is a rainbow. Nay, the mist that flies from the whirling of a mop makes a rainbow: these effects are so common they admit of no dispute; but to conclude from thence that light is made of such colours (in my opinion) is calling those things causes which are but effects. The various and numberless effects produced by

the reflection of light, reflections of its reflections, and its passing through lucid and transparent bodies of convex, concave, angular, and other forms, I doubt, are too many, and some of them too far removed from the speculative knowledge of mankind to be rationally accounted for. Nay, the best account I can find for the rainbow is from *Genesis*.

Affertor.] At this rate you question the truth of the *Newtonian* philosophy; nay, you absolutely dissent from it; but you must give me leave to tell you that the *French* panegyrist (who understood these matters very well) says, that if all *Europe* was on one side of an argument, and Sir *Isaac Newton* on the other, the dispute would be determined in his favour.

Objector.] All *Europe*! why he himself is one of that all, and so must give his opinion against himself.

Affertor.] I suppose he means all *Europe* excepting himself.

Objector.] I'll tell you how I suppose it is, there are a sort of people in *Europe* who will give their opinions in matters of which they are entirely ignorant; and are more tenacious and obstinate (without comparison) than those who act from their own judgment. To endeavour to shew them their errors by argument is to no purpose, it being impossible to convince people they are either right or wrong in matters they have not capacity to understand; so that they are invincible advocates to the party they espouse. These (who are very numerous) always side with the most fashionable opinion. And if it is they (who in fact have no opinion at all) whom the *French* panegyrist means by all *Europe*, I believe it will be as well to grant what he says, as to contest it with him. Yet it is somewhat extraordinary (although they have

no

no opinion) that they should give that *no opinion* against themselves. But *something too much of this*. This I have to say for myself, that I neither believe nor disbelieve any thing I do not understand, and I must be so plain as to tell you that I do not understand any of your arguments, at least I do not understand that they are true. Nay, so far am I from believing that light is a substance, and has motion, weight, measure, and all other sensible qualities of matter, that I believe it has none of them, or is indeed any thing more than a reflection, which I will endeavour to convince you of as follows.

Light and heat are effects from fire, *i. e.* wherever there is fire there is light and heat. The heat acts upon bodies, light (which I shall confine myself to) is imprinted on or reflected from all opake bodies within its reach, in proportion to the magnitude and intensity of the fire; which reflection is capable of giving light (though in less proportion) to other opake bodies which are not enlightened by the fire (in the manner the earth enlightens a new moon) and that body to another, till the light is quite exhausted: and where there is nothing to reflect it, light has no existence at all. This would be plainly seen if a large room was to be made quite dark, and a parcel of small orbs placed in it at different distances, and a light or candle in the center; where the hemispheres next the candle would be so enlightened that you might see every thing on them, and if a small insect was on one of them, it would have light to see every thing near it. In the same manner supposing the earth to be enlightened by the sun, all the inhabitants on the enlightened hemisphere must have light to see every thing around them, and the intermediate spaces between the orbs would have no light at all. So that I say light is a reflection from

from all opake bodies, and nothing else; for where there is nothing to reflect it, it has no existence at all.

Day-light may be called a whiteness caused by the sun (whose brightness, in clear weather, is the perfection or highest degree of white) which as I have said is imprinted on, or reflected from, all opake bodies, in proportion as they are nearer to, or farther off, from it; *i. e.* the whiter any opake body is, the more susceptible it is of light, and the darker, the less.

For instance. In day-light, when the ground is covered with snow, if the sun shines, the white of the snow is so intense that our eyes will hardly bear looking at it, but when there is no snow the ground itself has no such effect. And if, instead of being covered with snow, the earth was to be covered with any thing dark or black, though it would even then receive and reflect a great deal of light, yet it would be in far less proportion than if it was covered with snow or white: the reason is, black is not so susceptible of light as white is. For light itself being white, any object that is white, or nearest to white, is more susceptible of it than any one which is darker. As a body that is hot is more susceptible and ready to take fire, than one of the same quality which is not so hot.

This may be also seen from the light of the stars, for if there is ever so little light (as in a dark night) a white object may be discerned, where one that is darker cannot.

That the light or brightness which is seen on a full moon, is a reflection of the light of the sun from the surface of the moon, I think is not to be doubted. As it is almost certain, the moon is not a body of fire to emit light from it, as the sun is. Therefore, I say, its light or brightness can be nothing

thing but a reflection of the light of the sun. And that that reflection or brightness must make the inhabitants of the moon (if there are any) to be in plain day-light, the very looking at a full moon is sufficient to evince.

The same may be said of our earth. For the hemisphere towards the sun must be enlightened in the same manner the moon is; which light, considered as above, can be nothing but a reflection from the sun.

So that tho' the sun is the cause of light to our earth, yet it is by the reflection of its light from the earth's surface (not from the sun itself) that we see every thing about us. And was it not for that reflection, the light of the sun would be of no use to us, for our eyes will not bear looking at the sun; and without looking at it we could have no light from it. Nay, so very far is the light of the sun from being helpful to our seeing, that when your face is turned towards it, it hinders the sight. This any one must be sensible of, that has held his hat to hide the sun when he has been looking at any thing against it.

The same may be said of moon-light. For it is not from the moon, but the reflection of its light from the surface of our earth, that we see every thing around us. And the same may be said of the stars in star-light.

In reading by candle-light, it may be observed that the light we read by is not from the candle, but the brightness of the surface of the paper which is reading. For if you take two papers with writing or printed letters on them, of the same sort and blackness, and dip one of them in oil, or any thing else to make it transparent, that the light of the candle may pass through it, and do nothing to the other; and then place them in the same position, and at the same distance from the candle, it will
be

be found that the letters or writing, or any thing else on the paper, which is not transparent, will be much plainer to be seen and read, than those on the transparent one. The reason is, the surface of the paper which is not transparent reflects the brightness from the candle more than the other which lets the light, or part of it, pass through it. So that the more or less reflection there is, the more or less light there is to read by, without considering the candle any otherwise than as the cause of that reflection.

The enumerating proofs that light is a reflection would be endless. I shall therefore leave the rest to every persons own observation, without mentioning any other.

And now it is difficult to me to conceive why or to what purpose these gentlemen have given light motion, substance, weight, &c. The alternates of light and darkness being rationally accounted for without either of them. For I think it is very clear, that the light of the sun must be always existing. And from the nature of a globe it is as clear that the hemispheres of the orbs next the sun must be enlightened, and those from it must be dark. And their (the orbs) being in perpetual rotations must make an alternate succession of light and darkness, *i. e.* day and night, to all parts of them for ever, or while they and the sun have existence. So that, I say, I can't see the least necessity there is for light to have any of these qualities. Nay, to me, I declare they seem quite repugnant to the nature and use of it.

For if light had motion, would it not be subject to the winds, and carried away from some parts of the earth, leaving them almost or quite dark, while others had too much of it?

If it had substance, how could it ever be dark while any of that substance was existing?

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If it had weight, would it not subside and fall to the earth? And in short, if it had either of these, or any other of the qualities of matter, I think it must be subject to the same laws, and actuated in the same manner, matter is. The assertion is, *that light is material*; so that it must be subject to the laws of matter without any reserve.

Nor do I think it will mend the matter to urge that the particles of light are of so minute and imperceptible a nature that they are too light to be affected by gravity. Because the lighter any matter, or part or parts of matter is, or are, the more subject it, or they, must be to the winds. And motion is one of the principal qualities attributed to it.

Perhaps, I have taken too little notice of the dispute, whether light is instantaneous or not. My opinion of that matter may be known as follows, *viz.* It appears very clear to me, that the light of the sun is, and has been, at all times and in all places (as far as it extends) ever since the creation, where there is any thing to reflect it, and where there is not it has no existence at all. So that all the orbs, within its reach, may be said to roll in light, for it has never been off from one part or other of them. Therefore, the whole dispute appears to me to be an absurdity. For how is it possible to know whether light is instantaneous or progressive, when it has never been withdrawn, and consequently never moved either backward or forward.

My saying *within reach of the sun's light*, is because I would break in as little as possible on the present system: though I have not the least reason to think the sun does not only give light to all the orbs that are to be seen with our eyes or the help of the best glasses, but to orbs innumerable more. I am rather convinced it does, and am astonished

to find such numbers of people all agreeing in such a scanty and limited opinion, as to confine it to six or seven planets and their satellites ; when, according to their own notions, it is capable of giving light from all points of its surface, and in all directions. But of this I design to speak more largely in another place.

Having all along considered light as a reflection on opaque bodies, it may not be amiss to mention how water, which is a lucid or transparent body, is enlightened.

Water is a mirror, and the light we see on it is the appearance of the clouds, and every contiguous object around it, reflected as from a looking-glass. The sun is as intensely bright (or nearly so) in the water, as in the heavens ; and all dark objects are as black in the water as on land. This is speaking in general of the ocean and large collections of water. But some waters which are transparent, and others which are fouled with soils of any kind, may be excepted.

For if water was quite transparent as air is, the bottom under it would be seen as plain, and enlightened in the same manner, as if no water was over it : but I believe there is no such water at all, for the clearest sort that is (if it has depth enough) I imagine will appear as a mirror.

Water which is so transparent that the bottom may just be seen through it, has light partly reflected from its bottom, and partly the light of the clouds, and objects around it reflected on it as from a mirror, though both but faintly.

Water mixed with mud, soil, &c. has the appearance of the soil it is thickened with, and has light reflected from it almost the same as if it was an opaque body of the same colour with the soil ; which light is fainter or stronger in proportion to the quantity of soil which is in it, *i. e.* when there

there is but a small quantity of soil the water shews the clouds and objects around as in a mirror, though but faintly; and when it is very thick, the water has the colour of the soil it is fouled with, and reflects neither clouds nor any thing else from it, as from a mirror.

Ships, boats, or any other substance, has light reflected from them in the same manner on the water as on land.

On the Twilight.

BEFORE I come to the matter, it may not be unnecessary to mention the expansion of light.

That light naturally expands and spreads itself may be seen when it breaks thro' a cloud, where if it begins at a point when it first comes out, it expands itself to a prodigious breadth. And it may be also seen by observing the light of the sun when it comes in at a hole in a room, where if you hold a piece of paper against the hole, or a little with inside of it, you may with a pencil mark its exact size; then carry it to the farthest end of the room from that where the light enters, and hold it that the light of the same hole may appear on it, and you will find the light at that part considerably broader, even in a common room. From this I infer, that whenever light touches on the outside of a globe, or any thing else, it changes its direction, which I imagine is the cause of the Twilight.

For if any one observes when the sun shines on an artificial globe, he will find that the light reaches beyond the hemisphere of it, and declines away in such a manner that it is difficult to know how much it reaches farther; from which it naturally follows, that if any thing is placed to receive

the shadow of the said globe, it will be found (at any considerable distance) to measure less than the globe which causes it ; and the greater the distance the shadow is from the globe, the less it will measure, 'till carried so far as to have no shadow at all, which must be caused by the aforesaid expansion. For if there was no such expansion, the light would break off exactly at the diameter or middle of a globe, and consequently there could be none at all after the sun was beneath the horizon ; but, with the aid of the expansion, light (as I have said) changes its direction, and is carried three or more degrees beyond the hemisphere, where it otherwise would have broken off. So that the light must continue after the sun is out of sight, till the globe has roll'd these three degrees. Now to the inhabitants under the line at the time of the equinoxes, the earth turns at the rate of one degree, or thereabouts, in two minutes and a half ; so that if the expansion carries light three degrees beyond the hemisphere, the Twilight will continue there seven minutes and a half, or thereabouts, after the sun is out of sight : but to the inhabitants under either of the poles it is quite different ; for the sun advances or goes away but slowly to or from them, even at the time of the equinoxes, when it makes its swiftest progress ; it being then seven days and a half in going three degrees, and consequently it must be twilight all that time.

But for all this, there would yet remain an inconvenience in the change from light to darkness ; for although the expansion carries light beyond the hemisphere of a globe, yet the change from light to darkness would be sudden and very inconvenient for the inhabitants of the earth, which is still remedied by the aforesaid expansion. For it may be observed, that as light expands itself, it weakens in proportion to the expansion ; which may be

be often seen when it breaks through a cloud, as aforesaid ; for though it is quite bright where it first breaks out, yet where it falls, or should fall, on the earth, it shines but very faint, and often has no shine at all ; and if a small hole is made in a thick piece of paper, and held for the sun to shine through, it will be very plainly seen by placing any thing to receive its light, that the farther it is carried from the paper, the broader and fainter the light will appear, 'till it is carried so far as to give no light at all : this may be done in a common room.

If any one observes and considers the moon at any time between the full and change, he will find that the light where it parts from darkness, is not with an edge, as the outside is, but declines away in the same manner as it does on an artificial globe ; so that the moon has Twilight, and probably all other orbs, as well as the earth. I do not know whether I have expressed myself so as to be understood, but I refer to the experiments which I think are very clear.

I have made no reply to the reasons given for the cause of the twilight in the present theory, because I think they hardly deserve any.

One of them is, that the scattered rays of the sun is the cause of the twilight, to which the very mentioning scattered rays is a sufficient confutation.

Another is, that the twilight is encreased by heat, and hot countries have most of it ; if that be true, the inhabitants under the line, without comparison, should have more than those under the poles.

Another is, that the rays striking on the upper or outer part of the atmosphere, causes the twilight. If that is true, when the air is thickest there should be most twilight, because the thicker
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the air is, the more capable it must be of receiving and reflecting light. Now it is very plain that the twilight is seen plainest and seems to continue longest in clear weather.

Note, I have considered this part of the subject only at the time of the equinoxes, because it is much easier to be understood by confining it to that time, than if treated more at large. But when the true continuance of the twilight is known to the inhabitants under the line and at the poles, tables may be made to ascertain how long it continues in every degree of latitude at that time; and then it will not be very difficult for any one acquainted with such matters, to enlarge them for its continuance at all other times of the year.

My mentioning light's being carried three degrees beyond the hemisphere of a globe, is because I think it cannot be much less, but it may be more, or perhaps less, for aught I know to the contrary, having never had an opportunity to make proper observations to determine the matter any otherwise than by guess. If it is two degrees, the inhabitants under the line will have twilight five minutes, or thereabouts, and those under the poles five days. If three degrees under the line, it will be seven minutes and a half, and under the poles seven days and a half. If four degrees, under the line it will be nine minutes, and under the poles nine days, &c.

Nor is the twilight the only advantage arising to the heavenly bodies from the expansion of light. There appears to be another very obvious one, *viz.* was it not for the expansion, every orb that is nearest the sun would carry their shadows as broad as their own magnitude to the utmost limits of the extent of the sun's light, and would eclipse all others, though at ever so great a distance from them, whenever they happened to be on right

lines between them and the sun. But by the aid of the expansion this is prevented, because the expansion makes all the shadows of the heavenly bodies conical *. So that although the earth (when it is between the moon and the sun) eclipses the moon, yet a planet at a greater distance, although in the same situation, may not be at all eclipsed by it; and perhaps it may not be an improbable conjecture to assert, that the spots in the sun are orbs in such like situations as we find those nearest to it are so much smaller than those at greater distances from it.

On Refraction.

SOME of the chief arguments in favour of refraction, are as follows. ‘ If a star be in the zenith of a spectator upon the earth, a ray coming from it to his eye falls perpendicular upon the spherical surfaces of the atmosphere, and will therefore proceed in a straight line without being refracted. And if a star be in the horizon of an observer, a ray coming from it to his eye, suffers the greatest refraction, for two reasons; First, the ray falls upon the surface of the atmosphere with the greatest obliquity; Secondly, it passes through the lower and denser part of the air.’ *Barrow.*

In these assertions there seems to be a reserve, for when a star in the Zenith is mentioned, then, ‘ *a ray falls perpendicular upon the spherical surfaces of the atmosphere.*’ But a star in the horizon, ‘ *a ray falls on the surface of the atmosphere,*’ (not spherical surfaces) because to have passed through the spherical surfaces at both times alike, perhaps

* In the explanation of eclipses, the conical shadows are said to be caused by the sun’s being larger than the earth, moon, &c. which I shall not dispute in this place.

haps would not have suited the hypothesis quite so well ; though I declare I do not know where a ray can come from, if it tends to the earth, without passing directly, (not obliquely) through the said spherical surfaces. Thus far must be granted, that the situation an observer is in when he views a star on the horizon, a ray may be said to fall obliquely on the earth ; but sure the earth and the atmosphere are different things, for the ray that falls on the earth passes through the atmosphere. In my opinion this affair would be clearer stated, if an observer was to be considered as looking thro' the atmosphere at a star in the zenith, and on the horizon ; because then it will be found that the sight must look directly (not obliquely) thro' the spherical surfaces in all directions, as well on the horizon as in the zenith ; only it has a greater length of them to pass thro' on the horizon than in the zenith. So that if the sight looks crooked at one time (in my opinion) it must do the same at the other. And if a ray passing through the lower and denser part of the air has any effect that makes our sight look crooked, I think there must be different degrees of it, for it is very certain that the atmosphere is more dense at some times, than at others ; but I believe no true observation was ever made, that did not make the sun, moon, and stars, have the same refraction, (as it is called) when the atmosphere was most dense, as when it was most rare.

As what I contend for here, is only that the sight looks quite straight through the atmosphere, at the sun, moon and stars, as well on the horizon, as in the zenith, it would be foreign to my purpose to take any notice of the refractions in optics (where light passing through transparent bodies if their surfaces are not planes) either diverges or contracts itself ; and consequently all objects
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look'd at through these bodies are magnified or contracted; because, I think the spherical particles can no way be concerned in the matter.

However, water, which may be composed of spherical particles, and as I have never met with the reason why rocks, shoals, &c. appear elevated to the sight more when under water, than they are in reality, I will leave my subject a little, and venture my opinion on it; which is as follows, That the bottom of any place (looked at thro' a body of water) is elevated to the sight, may be known by holding a straight stick perpendicularly in a basin or tub of water, where it may plainly be perceived, that the part of the stick which is under the water appears shorter in the water, than when out of it; and if the stick is laid on the brim or edge of the basin, or tub, with a declivity, letting it reach as far to the other side from which it rests on as it can, it may also be seen that the part under water will not appear straight with that out of it, but changes its direction, and seems as if it was bent upwards from the bottom; which makes it plain that the bottom appears raised by its being look'd at through a body of water. And the reason why the bottom appears raised, I imagine is the weight or gravity of the water: for water, large or small quantities, (was it not for its weight or gravity) would be globous, and in that form a stick, or any thing else in it, would appear of its proper length and straightness. But its weight or gravity alters the globous form, and makes it flat; so that objects appear shorter when held in it perpendicularly, and (was it free from pressure on its sides) they perhaps would be longer when laid horizontally.

Mr. *Derham* in his *Physico-Theology* says, that distant lands are raised up and carried into the air by refraction. So that his refraction, (instead of

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However, water, which may be composed of spherical particles, and as I have never met with the reason why rocks, shoals, &c. appear elevated to the sight more when under water, than they are in reality, I will leave my subject a little, and venture my opinion on it; which is as follows, That the bottom of any place (looked at thro' a body of water) is elevated to the sight, may be known by holding a straight stick perpendicularly in a bason or tub of water, where it may plainly be perceived, that the part of the stick which is under the water appears shorter in the water, than when out of it; and if the stick is laid on the brim or edge of the bason, or tub, with a declivity, letting it reach as far to the other side from which it rests on as it can, it may also be seen that the part under water will not appear straight with that out of it, but changes its direction, and seems as if it was bent upwards from the bottom; which makes it plain that the bottom appears raised by its being look'd at through a body of water. And the reason why the bottom appears raised, I imagine is the weight or gravity of the water: for water, large or small quantities, (was it not for its weight or gravity) would be globous, and in that form a stick, or any thing else in it, would appear of its proper length and straightness. But its weight or gravity alters the globous form, and makes it flat; so that objects appear shorter when held in it perpendicularly, and (was it free from pressure on its sides) they perhaps would be longer when laid horizontally.

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shewing the sun, moon and stars, when they are beneath the horizon) must hide them before they are on it.

But the question is, why are the sun, moon, and stars, seen when they are beneath the horizon? Which to me is so very plain, that I wonder the least difficulty should ever be made about it.

Let any one only consider the situation an observer is in when he views the sun, moon, &c. on the horizon, and he will find that the sight must be carried beneath them; indeed if the earth, instead of being round, was quite a level plane, then our sight would be carried directly over that plane, and consequently the sun, and all other objects must be hid, as soon, or rather before they are on the horizon. But the earth is round, and at the distance our sight is carried, (which by the aid of our height) may be thirty or forty miles, the round must be something beneath a level; and supposing it to be but an hair's breadth, even that in such a prodigious space as there is between us and the sun, moon, &c. it (the sight) must be carried beneath them; which I think is too plain to need any illustration.

An Examen of Dr. Halley's Abstract of the Theory of the Tides.

IN this abstract, the ebbing and flowing of the sea is imputed to the gravity of the earth being weaken'd at the point where the moon is vertical; because, by the water's being swell'd at that point, they (by the motion of the earth) are said to be carried round it, which causes the tides. This (with an allowance for the water's being carried a little faster than the motion of the earth by the moon's diurnal

diurnal motion) I take it, must be the author's meaning: And which in my opinion needs no other confutation than there being two tides in about 25 hours; because it is very certain that the moon cannot be in two places at the same time. And that the gravity of the earth being weaken'd at one part, should be the cause of its being weaken'd at another, at so great a distance, and so diametrically opposite to it, is what I think no one can believe. Nor do I conceive how the waters can be thought to form an oval, as mentioned in the aforesaid abstract; or indeed how the waters on the hemisphere of the earth, opposite to that where the moon is vertical, can be at all affected by her, even was it to be admitted that her gravity did affect the earth.

Nor does this agree with the currents, for tho' they always run one way, yet many, or most of them, (as I have been informed) have a rise and fall of the waters, which correspond as regularly with the moon as the tides does in the *Thames* and *Medway*, without mentioning the *Nile*, and many other irregularities which are found in the seas, which could not exist, if the waters were actuated and carried round the earth by the moon in the manner aforesaid.

But let us enquire a little farther into this matter; the centripetal force, attraction, and the weight of bodies, all appear to me to be comprehended in the word gravity. The centripetal force is the same as when it is said, the earth is surrounded with such a band as gravity; attraction, when the planets are said to be within the activity of the attraction, or gravity of each other. The weight of bodies, in my opinion, agrees best with the definition, which says, gravity is the natural tendency or inclination which bodies have to a center. But however these powers may be looked
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on as one and the same, yet to me they admit of very clear distinctions. For it is possible the earth may be kept together by such a band as the centripetal force, and yet have a quality of attraction; and it may attract, and yet bodies have a natural tendency towards it by their weight; and with regard to the planets gravitating to each other, they may attract each other, and they may have a natural tendency to each other by their weight; tho' to me, I declare it appears very unnatural to conclude any thing in favour of either of them. For if the sun, earth, moon, &c. was within the activity of the attraction, or had a natural tendency towards each other by their weight, I can see nothing to hinder them from rushing on each other: or first (if it is done by attraction) that which had the least of it, to that which had the most, and so on till they were all got together.

And leaving out the rest of the planets, what absurdity does it create in only considering the sun, earth, and moon, as having a power of attraction on each other. For if the influence of the sun was so great as not only to raise so large a body of waters as the ocean on our earth, but to reach so far as to affect the moon when at the full, I think at the change she (the moon) could not support herself in her orbit, she being a far less planet than the earth, and much nearer the sun at that time, and only supposing it capable of moving her but the thousandth of a thousandth part of an hair's breadth, even that (by such a power as gravity) must in process of time bring them together. Nor will it mend the matter to consider the gravity of the sun and planets as being in proportion to their magnitudes. For then, if the influence of the moon's gravity could reach the sun, the gravity of the sun would (I imagine) draw the moon to the sun with almost
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as much ease as an amber bead, when rubbed, does a particle of dust. Nay, even the earth would be too hard for the moon.

And if the gravity of the earth was so much weakened as to raise the ocean; surely all light bodies, such as feathers, dust, chaff, &c. (which will but just stay with us as it is) would not gravitate at all. Nor is it reasonable to think the power which could raise the seas, would leave ponds, gutters, &c. undisturbed, supposing there was a sort of gravity which affected the waters only.

And now for the spring-tides, which being higher than others, requires somewhat more than the moon to weaken the gravity. And here it is the assistance of the sun is called; for at the time of new moon, which is one of the seasons for spring-tides, the sun and moon are both vertical together, and so weaken the earth's gravity more than when they are not. But even this is hardly probable, because (supposing the sun to be concerned in the matter) the new moon would prevent its influence, she being at that time right between the earth and sun; and more especially at the time of a solar eclipse. And at the full moon there are spring-tides again, and then the earth is between the sun and moon, so that they must hinder each other by drawing two different ways.

Again, the equinoctial spring-tides are said to be higher than the rest, because the earth is nearer the sun at those times than at others; tho', when the tides are not on the carpet, then the earth is nearest of all to the sun at the time of the winter solstice, and yet the spring-tides run very low at that time. However, my opinion is, that the earth is at all times at the same distance from the sun, which the following argument I hope will sufficiently evince. *viz.* I think it must be very evident (to any one who

who is acquainted with the nature of the globe) that when it is * midsummer here at *London*, it is midwinter in $51^{\circ} 31''$ latitude in the southern hemisphere; and when it is midwinter there, it is midsummer here. How then can one part be nearer to, or farther off from, the sun, than the other, without destroying the uniformity which is found between the two hemispheres?

In a theory of the tides, I should have expected to have found not only the state of the waters all over the earth, but the reason why there are tides, currents, gulphs, &c. why they are confined to particular parts of the earth, and to have been shewn the necessity there is for them. Of which, the abstract is wholly silent. Nor do I think the state of the waters are sufficiently known for such a purpose.

The constant adherence of the tides to the moon sufficiently evinces, that they are influenced by that planet; but the difficulty is to know by what power she acts; for I have no notion at all of the gravity's being weakened: nor if it was, do I think it could answer the purpose of making tides; it would only lift the waters up where she was vertical, which would settle them again as she went from them, without forcing the whole ocean round the

* This being an extensive error, I shall say a little more on it in this place, which may save me the trouble of doing it at another time. Because there are $7\frac{1}{2}$ days less between the equinox's in winter than in summer, I find it is concluded that the earth must go swiftest at that time by about a $\frac{1}{85}$ part. But, as I have said before, it is winter and summer on the different hemispheres at the same time; so that one part cannot go faster nor slower than the other, without the earth is parted in the middle. Besides, if the earth goes faster in the winter by a $\frac{1}{85}$ part, the days must be an hour an half or more shortest at that time, reckoning from meridian to meridian, which may be brought to a fair decision by having a 24 hour-glass made and tried at both solstices.

the earth : besides, I much question, whether the seas are not too much thwarted by the lands for such a process to go on regular as the tides does, even was it to be granted that the moon had power enough to force the whole body of waters before her all round the globe.

It appears to me rather of the two, that the moon acts by a repulsive, than an attractive power ; though it may be by a power which neither attracts nor repels, but only stops the course of the waters. Nor do I think it at all impossible but that the connection between the earth and moon may be actuated by powers of which our senses have no idea.

By what power the moon acts is not very clear ; but she appears to me to be a regulator of the waters, which keeps them within bounds : and, without which, many parts of the earth, which has tides twice in 25 hours, would at sometimes be overwhelmed by inundations, and at others have no waters at all come near them ; of which, at some other opportunity, I design to speak further : where I believe I shall shew, with some probability, the cause of the ebbing and flowing, and the reason why there are two tides in about 25 hours. But, as some parts of what I have to say, depends on matters not known in the present state of astronomy, I shall wave saying any more 'till I have introduced some of them on other occasions ; and conclude the whole with declaring, that I can find little or nothing (in the abstract) pertinent to the subject. Gravity is used, as some of the faculty do medicine, who jumble several ingredients together which they prescribe as an *universal panacea* ; and so, by wanting to cure every thing, they cure nothing ;

nothing; for the drugs hinder the efficacy of each other; when used separate, and rightly applied in proper disorders, they might have had proper effects.

F I N I S.



